PRESKITT, DONNA C. Strength Increase as a Factor in the Performance of a Gymnastic Skill. (1967) Directed by: Dr. Gail M. Hennis. pp. 67.

The purpose of this study was to determine whether or not an increase in abdominal and shoulder strength were factors in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics, to devise two exercise programs (prescribed exercise and apparatus exercise) for developing abdominal and shoulder strength and to determine if one program was superior to the other in terms of effectiveness and efficiency in developing strength and in resulting successful performance of the skill.

The cable tensiometer was the instrument selected to assess strength measures. Subjects for the study were college women enrolled in gymnastic classes at The University of North Carolina at Greensboro during the second semester of the 1966-67 academic year. The subjects were students who were unable to perform the skin-the-cat skill prior to the beginning of the study. The subjects were equated into two separate groups with each being assigned to follow one of the devised exercise programs. Each program involved a maximum time of ten minutes of exercise two days per week for a period of five weeks.

The results indicated that strength increase was a factor in the performance of the skill, but not the determining factor; that one exercise program was not superior to the other in terms of effecting an increase in strength; that the apparatus exercise program was more efficient in terms of time spent in practice by subjects who were successful in performance of the skill; and that the apparatus exercise program appeared to be the more

effective program in terms of the proportion of successful subjects within that program as compared to the prescribed exercise program.

STRENGTH INCREASE AS A FACTOR IN THE PERFORMANCE OF A GYMNASTIC SKILL

by

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APPROVAL SHEET

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CHAPTER I

INTRODUCTION

Beginning gymnastic students often experience a series of failures in an effort to learn apparatus skills. While teaching gymnastics to high school girls this writer became cognizant of the failure and apparent frustrations that students undergo as they attempt to perform new skills or skills that were once familiar to them.

As children they find their own apparatus. They hang from jungle gyms, skin-the-cat on tree limbs, jump over ditches, and walk on lines. They enjoy moving and playing and thus their strength for such is maintained. These children grow and develop; the fun type apparatus activity is minimized considerably or disappears completely as they grow into their roles as young girls and women. Through gymnastics, these students, confronted once again with apparatus similiar to that of their younger years, find that the skills they once enjoyed are now poorly performed--if performed at all. Usually the students are concerned; sometimes they ask why, and often they know without asking.

Physical education teachers need to be aware of the basic strength levels of their students before attempting to teach them a skill requiring strength beyond their individual level. If the student is to experience success in performance, then stunts should be selected carefully so that the student who lacks necessary strength will not be encouraged to try things that may prove to

be only a futile attempt, dangerous, or frightening. Certainly this does not mean that physical educators cannot teach new and progressive stunts.

It seems that often students are instructed to do various exercises in order to develop sufficient strength necessary to the performance of certain skills. Other teachers feel that strength involved in skill learning can be developed as rapidly and will be more enjoyable if the student is allowed to practice on the apparatus the skill to be learned.

The skin-the-cat skill is commonly used as a transition stunt in routines on the uneven parallel bars. Because of the difficulty that has been observed as gymnastic students attempt to learn this skill, this writer chose to undertake this study as an attempt to determine whether or not strength increase is a factor in the performance of the skill. Two exercise programs, both designed to develop abdominal and shoulder strength, were selected. These programs were selected in order to allow a comparison of the effectiveness of each in terms of strength development, and to determine whether or not one program was more efficient in terms of practice time and successful performance.

CHAPTER II

STATEMENT OF PROBLEM AND DEFINITION OF TERMS

I. STATEMENT OF PROBLEM

It was the purpose of this study to evaluate the increase in abdominal and shoulder strength following a prescribed exercise program and an apparatus exercise program and to determine whether or not strength increase was a factor in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics.

It was also the author's intention to determine which program (the prescribed exercise program or the apparatus exercise program) was more effective in terms of developing the strength of the abdominal and shoulder musculature as measured by the cable tensiometer. Another purpose was to determine which program was more economical in terms of student's practice time.

This study was undertaken with the hope that it would aid in some way the teacher's understanding of the nature of learning, the learner, and the skill to be taught.

II. DEFINITION OF TERMS

The following definitions were used in this study:

Skin-the-cat. This skill performed on the high uneven parallel bar in

gymnastics is described as follows: Facing away from the low bar and standing under the high bar, the subject jumps and grasps the high bar with a forward grip (palms away from the body). From a vertical hang, legs flex pulling knees to the chest, or legs whip forward as knees are pulled to a tuck position. The subject pulls hard with arms as the movement continues and body rotates in tuck position between the arms until the legs can be extended almost vertically toward the floor. The grip is then released and the subject drops to a straight standing position below the high bar.

Abdominal strength. Throughout this study the references to abdominal strength indicate the cable tensiometer measurement of the tension applied by the abdominal muscles to a taut one sixteenth inch steel cable.

Shoulder strength. Throughout this study the references to shoulder strength indicate the cable tensiometer measurement of the tension applied by the muscles to a taut one sixteenth inch steel cable.

Total strength. Throughout this study the references to total strength indicate a combination of abdominal and shoulder strength.

Successful performance. This term as used in this study refers to two consecutive performances of the skin-the-cat skill as defined above.

Unsuccessful performance. This term as used in this study refers to a subject's failure to perform the skin-the-cat skill at the conclusion of this study.

CHAPTER III

REVIEW OF LITERATURE

The teaching of motor skills is a primary purpose and responsibility of the physical education teacher. Included in this responsibility are certain knowledges that are inherent to the task of teaching. The teacher must understand the nature of learning, the learner, and the skill to be taught. To get a more complete understanding of the study undertaken, the author felt that a review of literature was needed in the areas of skill learning, methods of developing performance, strength gains, abdominal exercises, and strength testing.

Skill Learning

Studies have yielded significant conclusions regarding the teacher's understanding of the student and the important difference this makes in the way the students view themselves and the rate at which they learn. (20) "Learning is defined according to Harlow as '. . . not the mere algebraic summations of a near infinity of stimulus-response bonds. It is the formation of learning sets; it is learning how to learn efficiently.'" (53:100)

Studies by Wickstrom (60), Kulcinski (44) and Shay (55) were conducted to determine whether the whole method or the whole part method was more effective in teaching gymnastic skills. The Wickstrom study, in which one of the stunts presented on the horizontal bar was skin-the-cat, found no statistically

significant difference between the two methods of teaching with the exception of the back roll-snap down in favor of the whole method. The Shay study involved a comparison of the progressive-part method versus the whole method of learning a gymnastic skill. The whole method was selected as the best method because of timing and absence of forced pauses which are important factors in certain gymnastic skills.

Kulcinski compared the effectiveness of formal, informal, and combination methods of instructing college freshmen in fundamental muscular skills. This study suggests that the informal method of instructing, through individual help and instruction, resulted in a greater number of exercises learned per student.

Wells (14) in writing about human motion, states that the greatest hindrance to efficiency is unproductive muscular effort. The truly skillful performer, she says, is "one who habitually obeys the principles of both the anatomic and the mechanical aspects of human motion. . .he has learned how, and has made it his practice, to observe the principles of skillful motion." (14:332)

In order to teach effectively, the teacher must know and recognize the components of skillful performance. Lockhart, in a speech presented to the American Academy of Physical Education, March 9, 1967, stated that, "In order to learn, at least two things are necessary: (1) capability, and (2) motivation." (68:1) Strength and power for the task to be learned are important in the list of capabilities and characteristics of skillful performance. (14)

The importance of strength in athletics is not always obvious. In skills which do not demand a high level of strength, success in performance is experienced more easily. "In gymnastics, if the student lacks the strength necessary for a certain stunt he will never experience success in it until he develops the requisite strength through repeated practice." (2:7) Again, the teacher must be aware of the learner because no two gymnastic students will be at the same level of skill or readiness, or have the same learning rates.

Morehouse, in commenting on specificity, says that "The method of training to perform a skill event should be related to the dominant feature of the event." (9:57) Only recently have the physical educators, coaches, and athletes concerned with sports in which power is a factor, become cognizant of the advantages of achieving maximum levels of strength. (5) Baley, in his book, Gymnastics in the Schools, makes this statement:

> Undoubtedly, the biggest deterrent to success in learning gymnastic stunts is inadequate strength and flexibility. When students improve these qualities, they learn much more rapidly and consequently with greater joy and satisfaction. (2:v)

The student, while attempting the skin-the-cat skill involved in this particular study, must estimate the displacement of the limbs and body parts. Morehouse contends that these estimations are somewhat dependent on the physical effort involved during the judgment, and that greater accuracy depends on production of the necessary effort. (9)

Also involved in the learning of skills is a familiarity with objects to be used and the particular coordinations of body movement. "The coach or teacher

can provide guidelines, offer suggestions and counsel, but if he attempts to dictate he will succeed neither as coach nor as teacher. Individual differences must be respected if potential is to be realized." (2:13)

Methods of Developing Performance

Physical educators are usually plagued with large classes, lack of time for needed individual instruction, limited equipment, and failure to use time wisely. Often students fail to develop desired apparatus skills because of insufficient practice time or practice time that is not meaningful.

Several theories regarding skill development and skillful performance were found in the literature reviewed.

1) Morehouse - A skill exercise requires a fine coordination in the timing of the muscular contractions. As the movements of an exercise proceed, each muscle involved must contract or relax at the proper instant or the movement will be interferred with or mis-directed entirely. As learning of a skill exercise progresses, there is an improvement in the timing of the muscular contractions and relaxations that control the various movements. (9:52)

2) Wells - Skillful, efficient performance in a particular technique can be developed only by practice of that technique. Only in this way can the necessary adjustments in the neuromuscular mechanism be made to assure a well coordinated movement. (14:334)

3) Clarke and Clarke - . . . properly directed exercise is the only known means for acquiring the ability to engage in tasks demanding sustained physical effort. (4:105)

As previously reported in the skill learning section of this review, statements concerning training in relation to the dominant feature of an event, and unproductive muscular efficiency as a hindrance to efficient motion, were quoted from the writings of Morehouse and Wells respectively. Physical

educators need to be aware of the basic requisites of a skill in order to guide the student in skill learning. If the dominant factor of a skill or an event happens to be strength, and the student falls short in this area, then once again it is the job and responsibility of the teacher to ellicit from the student strength development prior to anticipating success in skill performance.

Clarke and Clarke report that:

> . . . too many boys and girls in our schools and colleges show clear indications of inadequate organic power, as reflected in early fatigue under a normal demand of muscular effort and muscular inefficiency reflected in poor motor skills, low strength indices, and lack of endurance. (4:107)

Many gymnastic activities call for strength to move the body while hanging from or supported on the hands. A gymnastic feature article written by Hillman reports that "Gymnastic activities can improve the low degree of upper body muscular efficiency which has been evidenced by national fitness tests." (36:21) Baley contends that:

> During apparatus work, muscle insertions become origins with a considerably greater resistance offered against the muscle (the body) than is offered in most team and dual games (the ball, racquet, or bat). This accounts for the well developed musculature of the experienced gymnast. It is particularly the muscles of the thorax, shoulder girdle, and arms which are developed through gymnastics. These are the very muscle groups which are most neglected in the more popular spectator sports in the United States. (2:11)

The skill involved in this study is a movement used often on the uneven parallel bars. Babbitt and Haas, co-authors of Gymnastic Apparatus Exercises for Girls, describe the bars as:

> . . . the feminine complement to the even parallel bars, emphasizing movement and rhythm over strength; it is better fitted to the physical capabilities of the female body. The lower center of gravity, prevelant in

> most girls, favors the many rotation movements on this apparatus and decreases the need for masculine-type strength in the shoulder girdle area. (1:59)

Baley does not support the idea of masculine-type strength; however, he does suggest that many gymnastic activities call for strength to move the body while hanging from or supported on the hands. (2) In describing skin-the-cat, he says that students unable to lift their legs to the bar have weak abdominal, iliac, and psoas muscles and need to develop these by doing sit-ups and leg raises.

Morford (49) surmised from his study on dynamic kinesthetic learning that ten minutes practice was adequate time for detectable amounts of motor learning to occur. Another study involving increase in body strength found that ten minutes practice or exercising per day yields significant increases in strength. (40) Hilsendager (37) conducted a comparative study of a calisthenic and non-calisthenic program involving practice intervals for ten days and found that this amount of time yielded significant differences in the comparatives. Hillman (36) suggested an effective and popular plan for a four week unit in gymnastics.

In establishing a program in which students may experience skillful performance in gymnastics, the teacher must decide not only on what, but on how, the student must practice. Once these things are understood, the teacher must then guide the student in the best and most efficient method of practice.

Strength Gains

A brief review of the literature concerning strength gain and methods of developing strength appeared pertinent to the procedure for conducting this study.

A study entitled "Strength, Power, and 'Feminity' as Factors influencing the Athletic Performance of College Women" was completed in 1938, and concluded as follows:

> From the results of this study it would seem first, that power, or the ability to contract muscles under load at maximum speed, and muscular strength are the two most important factors we measured, so far as their influence on athletic performance is concerned. (24:125)

> It would seem that the programs of physical education for girls may safely disregard the matter of build, and, if they desire to promote athletic ability, may safely concentrate upon developing the requisite strength, speed, and skill related to the performance of the athletic events. (24:125)

In 1938, Wettstone devised a test for coaches to predict gymnastic ability. Strength was a main factor in the test. A correlation between strength and ability yielded a correlation coefficient of .79. (64)

Anderson and McCloy (16) gave standardized skill tests to high school girls to determine if sports ability and skill could be predicted and to see what test elements were most closely allied with sports skills. The Sargent Jump, a measure of power, correlated highest with sports skills and ability. The conclusions from this research were in agreement with an earlier study by Anderson (15) in which she concluded that strength tests were not valid predictors of "athletic ability" of high school girls; however, she added that this conclusion did not demonstrate that strength was not a valuable element in the total motor ability of this age group.

Rasch and Burke, in discussing strength development as a part of athletic training claim that "Muscular strength is perhaps the most important of all factors in athletic performance." (11:436)

Steinhaus concurs that:

> The full attainment of skill often awaits the strengthening of certain key muscles which in specific coordination should alone carry the load. Until then, other muscles less advantageously attached assist, resulting in movement which is clumsier than necessary. (12:23)

Rasch and Burke (11), Steinhaus (12), deVries (5), Hettinger (6), and Karpovich (7) agree that in order to increase muscle strength, one must demand from the muscle work that is greater than the previous demands on that muscle. The term applied to this principle is overload. These researchers suggest that the overload may be accomplished by speeding up the movement (12), or simply using the body weight as resistance. (7)

Steinhaus (12) breaks the application of the overload principle into two categories. One he calls "formal overloading," the other "functional overloading." Formal overloading involves the use of weight training and heavy calisthenics to strengthen a muscle or muscle groups. Functional overloading refers to activity that overloads the movements used in the sport. Rasch and Burke comment on added weights as a means of overload in the functional category as follows: "While the procedures of this sort do invoke the overload principle, they clash with the principle of specificity of training." (11:439)

During the past few years there has been much controversy, speculation, and research completed comparing strength development by isometric (or

static) and dynamic exercises. Steinhaus contends that "A muscle will grow in strength whenever it is overloaded whether in concentric, eccentric, or isometric contraction." (12:323)

A study to determine the effects of dynamic weight-training exercises upon strength and speed of movement was conducted by Chui (25) in 1964. Seventy-two males were divided into three groups as follows: Group I - isometric contraction; Group II - rapid dynamic contraction; Group III - slow dynamic contraction. The cable tensiometer was used to measure strength gain on eight different measures of the training program. The results evidenced no greater gains in strength in relation to a specific method when the three contraction methods were tested in weight training exercises.

The Berger (19) study which compared static and dynamic strength increases after twelve weeks of training found that strength improved significantly more when training statically to improve static strength and dynamically to improve dynamic strength.

deVries (5) reports on a study done by Muller and Rohmert in which they showed that strength gain was not constant; gain was rapid in muscles with a low minimum strength; and rate of gain was slower in muscles trained nearly to potential strength. From the research reported, deVries concluded that during a short period of time, gain is greater in isotonic training than isometric. Also in isotonics, the entire range of motion can be worked in one contraction; there is psychological advantage in that the subject is not bored; he feels that he is exercising; and hypertropy and endurance is greater than

that gained through an isometric program. The author suggested that isometrics could be more advantageous if exercises could be done at different angles throughout a range of motion; however, he was of the concerted opinion that this would defeat the main advantage of isometrics, that of reducing the administrative time.

Abdominal Exercises

Because of the varied uses of so-called "abdominal exercises" and certain misconceptions about them, a brief review of the related research follows.

According to Morehouse,

> Abdominal muscles are the ones most frequently needing attention since these are not brought into play in most work or sport activities. Moreover, they are difficult muscles to exercise because the action that brings them into play most strongly, that of flexing the hip, is usually dominated by the stronger flexor muscles of the hip--the sartorious, rectus femoris, psoas major, iliacus, and the adductors. (9:68)

In a 1966 issue of the Journal of Health, Physical Education and Recreation, Soderberg (57) reported research on exercises for the abdominal muscles which involved references to the three major abdominal muscles, their origins, insertions, and actions as follows:

1) Rectus Abdominus
   Origin: Crest of the pubis and the pubic symphysis.
   Insertion: Cartilages of fifth, sixth, and seventh ribs.
   Action: Flexion of the vertebral column, particularly the lumbar region. (57:67)

2) Obliquus Externus
   Origin: Lower eight ribs
   Insertion: Anterior one-half of the outer lip of the iliac crest and the abdominal aponeurosis.
   Action: Flexion of the vertebral column (both sides), flexion of the vertebral column laterally, and also rotation, bringing the shoulder of

the same side forward (one side). (57:67)

3) Obliquus Internus
Origin: Iliac crest (anterior two-thirds), iliac facia, and the lumbar aponeurosis.
Insertion: Inferior borders of the cartilages of lower three or four ribs and the linea alba.
Action: Same as obliquus externus except bringing shoulder to the opposite side. (57:67)

Soderberg's report included the hip flexor muscles, commonly referred to as the iliopsoas, as being important to abdominal exercises. The psoas major, the psoas minor, and the iliacus are the three separate muscles which constitute the iliopsoas. The following description was given:

1) Iliopsoas
Origin: Upper 2/3 of the entire iliac fossa, inner border of the anterior iliac spine, transverse processes of all the lumbar vertebrae, borders of the 12th thoracic lumbar vertebrae, borders of the 12th thoracic vertebra through the 5th lumbar vertebra.
Insertion: The fibers pass over the crest of the pubis, ending in a tendon on the lesser trochanter of the femur.
Action: If the spine (trunk) and pelvis are fixed--flexion, adduction, and external rotation of the femur. If the thighs are fixed--flexion of the trunk at the hips. "However depending upon the stabilizing action of the opposing muscle groups, this action may be limited to the production of an increase in pelvic tilt and a greater lumbar lordosis." (57:67)

These descriptions were followed by this statement: "Both groups function to control the position of the pelvis as it mediates between trunk and thigh movement." (57:67) The fact that the abdominals do not cross the actual hip joint was stressed.

In order to determine the best exercise for the abdominal muscles, experiments were done with various popular sit-up exercises frequently referred to as abdominal exercises or tests of abdominal strength. These involved

straight and bent knee sit-ups, curl-ups, and full sit-ups with different leg positions, and exercises without assistance. It was found that certain body positions had influence on the participation of the abdominal and hip flexor muscles.

Soderberg cites one study as follows:

> Kendall (3) states that when the knees are bent the iliopsoas tension is released so that the pelvis may tilt upward and thus flatten the back (the first part of the sit-up). She also draws attention to the widespread misconception that action of the hip flexor muscles is eliminaed (sic) by the knee-bent position during the sit-up noting that the complete sit-up could not be accomplished without the hip flexors. (57:69)

The Soderberg report makes clear the research findings:

> . . . in light of the references cited, evidence seems to support the fact that the hip flexors can be instrumental in performing a full-sit-up, particularly when the subject is allowed to do the exercise while the legs are straight. (57:69)
>
> Anatomical facts and clinical findings support the conclusion that abdominal strength should not be tested by the entire sit-up maneuver, and particularly not with legs straight. (57:69)
>
> It appears inescapably clear that for testing and for strengthening the abdominal muscles the trunk curl is far superior to the sit-up maneuver. (57:70)
>
> . . . the trunk curl, with the knees bent so that the feet are flat, should be used both as the screening test for adequacy of the abdominal muscles and as an exercise for increasing the strength of that group. (57:70)

Broer, (3) in agreement with the above description of the trunk curl and its effectiveness in exercising the abdominal muscles, makes additional analysis of the exercise in terms of arm positions. An analysis of the exercise with arms reaching forward, folded across chest, hands behind neck, and arms extended above the head shows that the center of gravity moves upward from the

hips as the arms move upward. The shift of the center of gravity increases the difficulty of the lift because the weight is further from the fulcrum. In relation to this observation one may surmise that the position with arms extended above the head would incur a higher degree of difficulty; however, the strong tendency to swing the arms to the trunk actually makes the sit-up easier. Therefore, Broer concludes that the position with the hands behind the head is the most logical arm position for increasing the degree of difficulty of the exercise, provided the performer allows the elbows to remain out to the side throughout the movement.

An electromyographic study involving abdominal and hip flexor muscle activity during sit-ups performed with straight and bent leg positions indicated that under all circumstances the activity appeared first in the rectus abdominis. The hip flexor muscles did not become active until the scapulae were clear of the floor.

In another study (67) electromyographic records were obtained on the abdominal muscles of ten women during the performance of an exercise series. Specific muscles checked for action potential were the rectus abdominis and external obliques. The high magnitude of the action potential of these muscles indicated that the following exercises were effective in strengthening the abdominal musculature; V-sit, basket hang, side lying trunk raise, backward trunk lean, and curl-ups.

Another controversial abdominal exercise is the popular leg-lift. Soderberg says that this exercise may necessitate abdominal muscle contraction,

but he reports that electromyographic evidence does not support this as an abdominal strengthener. The report concluded that "If the subject cannot maintain the back in contact with the surface while doing the straight leg raise, perhaps the iliopsoas and not the abdominals are being strengthened." (57:69)

In analyzing the straight leg lift, Broer points out that:

> Since strong hip flexors are attached to the pelvic girdle and the thighs, effort to hold the long leg lever against gravity results in a pull against the pelvis which is transferred to the lower back. As in sit-up exercises, the great strain comes when the legs are closer to the floor or when the angle of pull (angle between muscle and thigh bone) is smaller. (3:359)

Thus it was suggested that this exercise be used with caution due to the possibility of strain occurring in the lower back if the abdominal muscles are not strong enough to act as stabilizers. (3)

Strength Tests

Physical educators have for years been concerned with means of assessing strength measures of pupils. These means have, and still do vary from subjective observation and appraisal, strength-performance tests, to the most valid and reliable research instruments. There are good reasons why strength measurements should be an important phase of the evaluation process in reference to the teacher, the program, and the student. Since a certain amount of strength is necessary to good performance in skills, then basic strength scores will have implication for the physical educator as he understands more about his students and plans the program accordingly. (8)

A comparison of four instruments (cable-tensiometer, Wakim-Porter

strain gauge, spring scale, Newman myometer) was done by Clarke in 1954. Results indicated that the cable tensiometer had the greatest precision for strength testing and proved to be the most stable and useful of the four instruments. Meyer and Piscopo (47) gathered data to determine the reliability of the manuometer test of push-up action against the cable tension test of the same action. Results indicated that the cable-tensiometer was the most reliable method and was more adaptable for use. The researchers suggested continuation of the reliability studies entailing cable tension testing in different positions of dynamic muscular activity.

The cable tensiometer was originally designed to measure the tension of air craft control cable. In 1945, Clarke and Peterson constructed tests for use with orthopedic patients. The instrument involves an application of force to create tension on a cable stretched between two set points. This tension creates offset on a riser and the amount of tension applied can be converted into pounds on a calibration chart. Clarke has worked on the tensiometer tests keeping them up-to-date through extensive research involving strength measures, body position and application of strength, certain strength relationships, strength decrement fatigue patterns, and effect of gravity on scores.

Thirty-eight different muscle groups can now be tested using the cable-tensiometer. "Clark reports objectivity coefficients for thirty-eight cable tension strength tests ranging from .74 to .99. Thirty-three of the coefficients are between .90 and .99." (8:50)

deVries correlated the strength of single muscle groups against the

total of twenty-two representative muscle groups and found that all correlations were positive and significant at the .01 level of confidence or better. He concluded: "Thus strength tests that use several of these muscle groups can estimate the general strength quite accurately." (5:313)

Berger stated that "Most tests purporting to measure total strength usually contain several test items." (18:431) The preceding statement was made in regard to a study in which a relationship of chinning strength to total dynamic strength was determined. Weight lifting involving all the large muscle groups of the body was used. A correlation coefficient of .846 was found to exist between chinning strength and the total score of the weight lifting group.

deVries in reporting on strength measurements refers to a study by Berger thus:

> A well controlled study showed that no significant correlation exists between isotonic and isometric measurements of strength gains. The result of isotonic programs should therefore be measured isotonically and the results of isometric programs should be measured isometrically. (5:311)

Berger, after completing the study quoted above, concluded with this statement: "Investigators studying the changes in strength resulting from training should consider carefully whether a dynamic or static strength test will result in more accurate information under the circumstances." (19:332)

CHAPTER IV

PROCEDURE

This study was undertaken to test the hypotheses that: 1) an increase in abdominal and shoulder strength is a factor in the successful performance of the skin-the-cat skill in gymnastics, and; 2) there is no significant difference in the effectiveness of the two selected programs (prescribed exercise or apparatus) for increasing abdominal and shoulder strength.

The procedures presented herein were conducted in relation to the following fourfold purpose:

(1) to determine whether there was an increase in abdominal and shoulder strength following a prescribed exercise program or an apparatus exercise program.

(2) to determine which of the two programs (prescribed exercise or apparatus) was more effective in developing the strength of the abdominal and shoulder musculature as measured by the cable tensiometer.

(3) to determine if an increase in abdominal and shoulder strength was a significant factor in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics

(4) to determine which of the exercise programs (prescribed exercise or apparatus) was more efficient in terms of the amount of time spent in the actual program

Selection of Skill

The skin-the-cat skill is frequently used in the routines by performers on the uneven parallel bars in gymnastics. Upon observing beginning gymnastics

students, the writer of this study became cognizant of the difficulty experienced by the students as they attempted to perform this skill on the high uneven parallel bar. This skill was selected in order that an attempt could be made to determine if strength increase and the exercise methods used were significant factors in the performance of the skin-the-cat skill.

Selection of Tests

An aircraft cable tensiometer, manufactured by the Pacific Scientific Company, Los Angeles, California, was selected as the measuring instrument for this study because of its reliability and validity in strength testing. Clarke, in devising and administering tests using this instrument obtained objectivity coefficients of .90 and above. (8) The particular tensiometer used in this study was calibrated to test a capacity of five to one hundred tension pounds. A maximum pointer facilitated the reading of the subject's score. The tension pounds were converted, by means of a conversion table, to actual pounds pulled. The calibration chart used for the conversion of scores may be found in the Appendix.

Abdominal Strength Test. Clarke's (29) recommended isometric abdominal strength test involving a slight abdominal curl position was selected as the test for an abdominal strength measure. The detailed description of this test may be found in this chapter under Administration of Tests.

Shoulder Strength Test. The shoulder extension cable tension test,

described by Clarke (29), was adopted as the shoulder girdle strength measurement. Recommended body position, angle of flexion at the shoulder, and proper strap positions for the test are described under Administration of Tests.

Selection of Subjects

The subjects for this study were women students enrolled in physical education at The University of North Carolina at Greensboro during the second semester of the 1966-67 academic year. On the first day of classes of the second semester, the investigator met with students in a beginning and intermediate gymnastic class to give a brief explanation of the purpose and length of the experimental study. The women students in the two classes were invited to volunteer as subject possibilities; all agreed to participate.

One week later the participants were given an opportunity to attempt the skin-the-cat skill on the high uneven parallel bar. The skill was explained in detail, and "successful" performance was defined. The skill was demonstrated and when all questions were answered, each girl was allowed several attempts to perform. Only those students who were unable to perform the skill were asked to continue as subjects for the study. Out of the thirty original volunteers, seven were able to perform the skill thus leaving twenty-three students as subjects.

Subject Grouping

A master schedule was devised for the initial tests on the tensiometer. Testing times ranged from 9:30 a.m. to 5:00 p.m. Two tests, one for

abdominal strength and one for shoulder strength, were given to each subject. All subjects were tested within a two day period by the investigator.

For each individual both test scores were converted to T-Scores and combined to yield a single score for each subject. The twenty-three scores were divided into two groups according to class and, as nearly as possible, according to rank. It was necessary in this experiment to have each of the two groups divided so that half of the subjects in each group were in the beginning class which met at 3:00 p.m. and half were in the intermediate class which met at 4:00 p.m. This was done in order to facilitate the use of the apparatus.

The Fisher's "t" test for significance was the statistical technique used to determine the equality of the two groups based upon the combined measures of strength for each individual as established by the initial tests on the tensiometer. The results yielded no significant difference between the groups allowing an acceptance of the null hypothesis at the 1 per cent level of confidence.

The apparatus exercise group was designated as Group I. Group II was designated as the prescribed exercise group. At the fourth class meeting of the semester, the investigator announced assignments to the two groups and met with each for instructions.

During the five week experimental period, five students involved in the study withdrew from the gymnastic classes thus eliminating four subjects from Group II and one from Group I. The total number for each group was seven and nine respectively. The Fisher's "t" test of significance was calculated between the new means of the reduced groups to determine their equality.

Again results indicated no significant difference between them. The null hypothesis was acceptable at the 1 per cent level of confidence.

Description of the Exercise Programs

Apparatus Exercises - Group I. The nine subjects in Group I were instructed as to the proper procedures for exercise on the apparatus. Two girls were allowed to exercise simultaneously and independently on the uneven parallel bars attempting and practicing the skin-the-cat skill for a maximum time of ten minutes per day. They were instructed to work from the high bar but were allowed to kick-up from the low bar while practicing. These Group I subjects were cautioned against remaining on the bars after becoming tired or reaching the point of fatigue. If this point was reached before the buzzer which signified the end of the maximum ten minutes of practice, then the time the subject had spent in practice was recorded on her individual score card. If practice continued until the buzzer sounded, the maximum time of ten minutes was recorded.

An electric GRALAB Model 172 Universal Timer with an automatic buzzer which sounded at the expiration of the set time was used for timing the exercise periods. The time could be read in minutes and seconds and each girl was instructed in making accurate readings.

As the subjects completed their exercise time on the bars the timer was reset and two other subjects began their practice time. Of the nine subjects in this group, four were in the 3:00 class and five were in the 4:00 class.

This distribution required and allowed use of the apparatus for approximately twenty minutes in the first class period and approximately thirty minutes in the second class period.

Prescribed Exercises - Group II. Curl-ups, push-ups, leg-lifts, mermaid and inverted drag were the selected exercises which were described and demonstrated for Group II. (See Appendix for descriptions). Before the exercise program began each girl was checked for correct body position, proper cadence, and scoring for each exercise. Score cards were issued and explained and procedures for the five week testing period were covered in detail.

The subjects were told that they were to exercise during each class meeting for a maximum time of ten minutes two days per week for a period of five weeks. They were allowed to attempt to perform the skin-the-cat skill on the high uneven bar before each exercise period which was held during the last ten minutes of class time.

In order to effect the overload principle, subjects were encouraged to increase the number and/or duration of the exercises done each day.

An electric GRALAB Model 172 Universal Timer was available for timing practice periods. Each girl was instructed in the accurate reading and recording of her individual time. If the girl did not work the maximum time of ten minutes, then she recorded her time and exercises on her individual score card. An automatic buzzer sounded at the end of the exercise period and those subjects still exercising stopped and recorded their time as the maximum ten minutes.

Of the seven subjects in this group, five were in the 3:00 class and

two were in the 4:00 class. Exercise time for these subjects was scheduled during the last ten minutes of their respective classes.

General Instructions. Subjects in both groups were told that if at any time while attempting the skin-the-cat skill a girl performed it successfully twice in succession, then daily practice times would be totalled and she would be retested on the tensiometer in the same manner as she was tested initially.

On Wednesday, March 22, at the class meeting following the expiration of the five weeks of the experiment the final tests were administered to those subjects still unsuccessful in the performance of the skill.

Administration of Tests

Prior to the administration of the initial tests, all instructions and descriptions of the tests were discussed with the subjects. A master test schedule, which involved two days with available test times ranging from 9:30 a.m. to 5:00 p.m., was provided so that each subject could select a time that was convenient to her class schedule. The administration of the two tests took approximately five minutes per subject.

Subjects were asked to report promptly at their scheduled time to the physical education research laboratory and to wear their physical education costume or clothing that would allow for freedom of movement. Upon entering the laboratory, the subjects were asked to remove any heavy over-sweater or jacket that could have been a hindrance in securing the proper strap position during the test.

The final tests were scheduled and conducted in the same manner as the initial tests. No assistance was needed in the administration of either test. The investigator administered the abdominal strength test first. After approximately two minutes of rest, the subject was given the shoulder strength test.

Abdominal Strength Test. An adjustable trunk strap (army surplus belt) with an interlocking clasp was fastened around the subject just under the armpits. The belt was tight and the clasp was secured at the center of the back between and just below the scapulae. A one sixteenth inch flexible cable attached to a welded link chain was fastened by a hook to the interlocking clasp on the trunk strap. (See Appendix, Figure 3.)

The testing table used was one designed for cable tension testing. The table top is padded and a twenty inch by seven inch slit is cut in the center of the table, beginning ten inches from one end. (See Appendix, Figure 1.) For this particular test, a sturdy hook was secured below the slit to a two-by-four strip in the frame of the testing table. The cable and link chain were dropped through the slit and attached to the hook. The appropriate link in the chain was selected so that the cable was taut. The trigger of the tensiometer was opened and the taut cable was passed between the two sectors and the riser. The trigger was closed and the investigator held the tensiometer steady while testing. (See Appendix, Figure 2.)

The subject was placed in a supine position on the table with the knees flexed just enough to allow the soles of the feet to rest on the table. The arms

were folded across the chest with hands grasping the upper arms. (See Appendix, Figure 4.) The subject was instructed to pull with as strong an effort as possible against the cable. (See Appendix, Figure 5.) A reading of the tension exerted was taken, recorded, and converted into pounds according to the calibration chart which can be found in the Appendix.

Shoulder Strength Test. Three sturdy hooks were placed in a vertical line on the wall four, six, and eight inches above the height of the testing table. The table end was placed perpendicular to, and approximately three feet away from the wall.

The subject assumed a supine position on the table with hips and knees extended and legs resting on the table. The right arm was flexed at the shoulder to 90^{o} and the elbow was flexed with the wrist in prone position. The free arm rested on the chest while an adjustable strap three inches wide was placed around the midpoint of the upper right arm. Attached to this strap was a one-sixteenth inch cable and a welded link chain. The proper link of the chain was hooked over the wall hook which allowed the cable to be taut and parallel to the floor. The tensiometer was placed on the cable by releasing the trigger, passing the cable between the two sectors and the riser, then securing the trigger. (See Appendix, Figure 6.) The investigator held the instrument in the left hand and used the right hand to stabilize the subject's right shoulder throughout the test. The subject was instructed to apply as much tension as possible in an attempt to extend the arm from this 90^{o} angle to 180^{o}. A reading of the position of the maximum pointer was taken from the dial of the tensiometer. This

reading was converted into pounds from the calibration chart shown in the Appendix.

Treatment of Data

The abdominal and shoulder strength measures obtained from the initial tests were each converted into T-Scores and combined to yield a single T-Score which represented a total strength score for each subject. After dividing the subjects into two separate groups, statistical procedures were used to determine the mean and standard deviation of total strength scores in each group. To determine whether or not the two groups were alike with respect to the total strength measures, the Fisher's "t" test of significance for small uncorrelated samples (13) was calculated between the means.

In order to determine any significant gain in abdominal, shoulder, and total strength measures, Fisher's "t" test of significance for small correlated samples (13) was computed between the means of the following: 1) subjects within each group; 2) combined successful subjects; and 3) combined unsuccessful subjects. The same test was used to determine whether or not there was a significant gain in total strength of the successful subjects within each group.

Fisher's "t" test of significance for small sample uncorrelated means was used to determine whether or not there was a statistically significant difference in the abdominal, shoulder, and total mean strength gains between the following: 1) Group I and Group II; 2) successful and unsuccessful subjects; and 3) successful subjects of Group I and Group II.

In addition to these tests of significance within and between the various groups, the Fisher's "t" test of significance for small uncorrelated samples was calculated between the mean strength scores of successful and unsuccessful subjects after initial and final testings.

Also with Fisher's "t" test of significance for small sample uncorrelated means, comparisons between practice times of various groups were determined.

CHAPTER V

ANALYSIS AND INTERPRETATION OF DATA

This study, conducted at the University of North Carolina at Greensboro during the second semester of the 1966-67 academic year, was designed in relation to the following fourfold purpose:

(1) to determine whether there was an increase in abdominal and shoulder strength following a prescribed exercise program or an apparatus exercise program

(2) to determine which of the two programs (prescribed exercise or apparatus) was more effective in developing the strength of the abdominal and shoulder musculature as measured by the cable tensiometer

(3) to determine if an increase in abdominal and shoulder strength was a significant factor in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics

(4) to determine which of the exercise programs (prescribed exercise or apparatus) was more efficient in terms of the amount of time spent in the actual program

Presentation of Findings

All subjects were given the initial tests of abdominal and shoulder strength as measured on the cable tensiometer. Each of these scores was converted into T-Scores and combined to yield a single T-Score which represented a total strength score for each subject. (See Appendix for the raw scores and T-Scores for all subjects.) The total strength scores were ranked in numerical order from high to low. From these ranked scores two groups were established,

as nearly as possible, by the split rank method.

The mean score for one group was 103.02 with a standard deviation of 19.47. This group was arbitrarily designated as Group I (Apparatus) and the remaining group, with a mean score of 106.25 and a standard deviation of 17.23, was designated as Group II (Exercise).

In order to determine whether or not the two groups were alike with respect to the total strength measures, the Fisher's "t" test of significance for small uncorrelated samples was employed between the means. The results did not yield a statistically significant difference between the means; therefore, it could be concluded that, in terms of total strength measures, the groups were equated. The data for the comparison of the two groups may be seen in Table I.

Groups I and II were given a maximum of two ten minute practice periods two days per week for a period of five weeks. During this time, Group I practiced on the apparatus and worked toward successful performance of the skin-the-cat skill. Group II, in turn, worked on the prescribed exercise program. Group II subjects were checked for successful performance of skin-the-cat on the high bar preceding and following each exercise period.

After a subject had performed the skill successfully, she was given the final tests on the tensiometer. Subjects who were not successful at the end of the five week period were likewise tested.

Tests of Significance

Fisher's "t" test of significance for correlated means (13) was used

TABLE I

COMPARISON BETWEEN GROUP I (APPARATUS) AND GROUP II (EXERCISE) ON TOTAL STRENGTH AT INITIAL TESTING

GROUPS	TOTAL STRENGTH			
	N	M	S.D.	t
Group I (Apparatus)	9	103.02	19.47	.3233
Group II (Exercise)	7	106.25	17.23	

to compute the significance of difference between the means of the abdominal, shoulder, and total strength gains of subjects in each Group. Also employed to these data was Fisher's "t" test of significance of difference between uncorrelated means. (13) These latter calculations were computed to determine whether the means of gains of the abdominal, shoulder, and total strength measures between Group I and Group II were statistically significant. The results of the "t" tests may be found in Table II.

The investigator was interested in knowing if there were a significant increase in any of the three strength measures after initial and final testing. Gains in abdominal strength were significant at the 5 per cent level of confidence in Group I (Apparatus). While subjects in Group II (Exercise) showed gains in this measure, the gains were not statistically significant. Shoulder strength gains were significant at the 1 per cent level of confidence in Group I and at the 5 per cent level of confidence in Group II. Groups I and II gained significantly in total strength at the 1 and 5 per cent levels respectively.

The differences in mean gains of abdominal, shoulder, and total strength between Groups were not sufficient to be considered statistically significant.

In order to determine the significance of difference in mean strength scores of successful and unsuccessful students, regardless of group, Fisher's "t" test of significance for uncorrelated means was used. As is shown in Table III, there were no significant differences in the mean scores of successful and unsuccessful subjects in either abdominal, shoulder, or total strength

TABLE II

COMPARISON OF STRENGTH GAINS WITHIN AND BETWEEN GROUP I (APPARATUS) AND GROUP II (EXERCISE)

GROUPS	N	STRENGTH GAINS					
		Abdominal		Shoulder		Total	
		M Gains	t	M Gains	t	M Gains	t
Group I	9	21.11	**3.06	7.00	*4.91	18.89	*5.57
Group II	6	16.43	2.29	10.57	**2.79	20.08	**2.93
Difference Between Groups		5.49	.68	7.19	1.49	4.14	.52

**Significant at the 5% level of confidence
*Significant at the 1% level of confidence

TABLE III

COMPARISON OF STRENGTH MEASURES BETWEEN SUCCESSFUL (9) AND UNSUCCESSFUL (7) SUBJECTS AFTER INITIAL AND FINAL TESTING

SUCC. & UNSUCC.	STRENGTH MEASURES					
	Abdominal		Shoulder		Total	
	Diff. of M	t	Diff. of M	t	Diff. of M	t
Initial Test	8.68	.87	2.00	.37	6.80	.69
Final Test	6.00	.75	4.00	.08	.39	.05

measures.

Combined successful and combined unsuccessful subjects were treated as two separate groups and scores were analyzed in order to determine and compare the abdominal, shoulder, and total strength gains of each. The data in Table IV indicate that the "t" values of mean abdominal strength gains were significant for both successful and unsuccessful subjects at the 5 per cent level of confidence. Neither the successful nor unsuccessful subjects showed significant gains in shoulder strength. The total strength gains of successful subjects were significant at the 5 per cent level of confidence as compared to the unsuccessful subjects with total strength gains significant at the 1 per cent level of confidence.

Again Fisher's "t" test for significance between uncorrelated means did not indicate a statistically significant difference between the abdominal, shoulder, or total strength gains of successful and unsuccessful subjects.

As is shown in Table V, the successful subjects within Group I gained significantly in total strength at the 5 per cent level of confidence. Successful subjects within Group II failed to show significant gain in total strength; however, the "t" value obtained in computing the difference in total strength mean gains between the successful subjects in each group was not significant.

Table VI shows that throughout the five week experimental period, the difference in the mean practice times between Group I and Group II were not statistically significant. These results indicate that, in terms of significant strength gains, one method (Apparatus or Exercise) did not appear superior to

TABLE IV

COMPARISON OF STRENGTH GAINS WITHIN AND BETWEEN GROUPS OF SUCCESSFUL AND UNSUCCESSFUL SUBJECTS

SUBJECTS	N	STRENGTH GAINS					
		Abdominal		Shoulder		Total	
		M Gains	t	M Gains	t	M Gains	t
Within Successful	9	18	**2.35	6	2.23	16.14	**2.76
Within Unsuccessful	7	20.43	**3.52	1.18	.79	23.62	*7.76
Difference Between Groups		2.43	.24	4.82	.94	7.48	1.04

**Significant at the 5% level of confidence
*Significant at the 1% level of confidence

TABLE V

COMPARISON OF TOTAL STRENGTH GAINS BETWEEN AND WITHIN SUCCESSFUL SUBJECTS OF GROUP I (APPARATUS) AND GROUP II (EXERCISE)

GROUPS	TOTAL STRENGTH		
	N	M Difference	t
Group I (Successful)	6	16.95	**3.22
Group II (Successful)	3	14.52	.89
Between Groups (Successful)		2.43	.18

**Significant at the 5% level of confidence

TABLE VI

COMPARISON OF PRACTICE TIME (RECORDED IN SECONDS) BETWEEN AND WITHIN GROUPS

	PRACTICE TIME		
	N	M (Seconds)	t
Between Groups			
Group I	9	3311	1.80
Group II	7	4549	
Between Groups (S)			
Group I	6	2917	.69
Group II	3	3760	
Within Group I			
Successful	6	2917	**3.05
Unsuccessful	3	4101	
Within Group II			
Successful	3	3760	.31
Unsuccessful	4	5141	
Combined Groups			
Successful	9	3197	**2.31
Unsuccessful	7	4695	

**Significant at the 5% level of confidence
(S) = Successful

the other.

It is of interest to note in relation to the above comparisons of successful and unsuccessful subjects that, in addition, a comparison of practice times between these successful and unsuccessful subjects showed that successful students spent significantly less time in actual exercise than did the unsuccessful subjects. This difference was significant at the 5 per cent level of confidence.

Table VI illustrates the difference in practice times of successful and unsuccessful subjects within Group I and Group II. It was noted that within Group I (Apparatus), successful subjects spent significantly less time in practice than unsuccessful students. This difference was significant at the 5 per cent level of confidence. The difference between practice times of successful and unsuccessful students within Group II (Exercise) were not significant. Therefore, the difference in Group I successful subjects seemed to be the determining factor which allowed the significant difference at the 5 per cent level of confidence in the previously discussed comparison of combined successful and combined unsuccessful subjects' practice time.

Interpretation of Findings

A computation was made to determine if there were a statistically significant difference between the total strength measures of each group before beginning the exercise program. The "t" value obtained between the difference of a mean of 103.02 for Group I and 106.25 for Group II was .32. This value

was not statistically significant and it was concluded that, in terms of total strength measures, the groups were equated.

After the final testing for strength measures, a comparison of strength gains within and between Group I (Apparatus) and Group II (Exercise) was made. Within Group I, the mean of gains in abdominal strength was significant at the 5 per cent level of confidence. Both the shoulder and total strength "t" values indicated significant gains at the 1 per cent level of confidence. Group II failed to show a statistically significant gain in abdominal strength. The gain in shoulder strength was significant at the 5 per cent level of confidence and the total strength gain was significant at the 5 per cent level of confidence. From empirical observation of these data as presented in Table II, it may appear that the Group I (Apparatus) gains were greater than the gains within Group II (Exercise). However, when a comparison was made between the mean gains of each group, the "t" values obtained were not statistically significant at or below the 5 per cent level of confidence. Since both groups showed strength gains in each measure and the differences between the gains were not statistically significant, it appears that neither exercise program (apparatus or prescribed exercises) used in this study was superior in achieving increases in abdominal, shoulder, and total strength measures.

The Successful subjects included all subjects who, at some time during the course of this study, were able to perform the skin-the-cat skill two consecutive times. The Unsuccessful subjects were those subjects who still could not perform the skin-the-cat skill at the conclusion of this study.

Statistical treatment of the mean scores of the Successful and Unsuccessful subjects at initial and final testings yielded no statistically significant difference in either abdominal, shoulder, or total strength measures. The subjects, whether successful or unsuccessful in performance, were equated in terms of the abdominal, shoulder, and total strength as measured in this study prior to, and following the exercise programs.

Further analysis of the strength measures of the Successful and Unsuccessful subjects indicated for both groups, significant gains in abdominal strength at the 5 per cent level of confidence. Neither group showed gains of statistical significance in shoulder strength. In total strength, the Successful subjects gained significantly at the 5 per cent level of confidence while the Unsuccessful subjects showed significant gains at the 1 per cent level of confidence. A comparison of the strength gains between the Successful and Unsuccessful subjects yielded, in all three measures of strength, "t" values that were not statistically significant at or below the 5 per cent level of confidence. This indicated that neither group was superior to the other in terms of strength gains.

The successful subjects of Group I and Group II were compared in terms of total strength. As the data on Table V indicate, the successful subjects in Group I (Apparatus) gained significantly at the 5 per cent level of confidence while the successful subjects in Group II (Exercise) failed to show significant strength gains. Although the successful subjects in Group II did not show significant gains, the comparison between the groups indicated that the

total strength gains of the successful subjects of Group I were not statistically superior to the gains of the successful subjects in Group II. Therefore, in terms of total strength gains of successful subjects, it appears that the influence of one program (apparatus or exercise) was not superior to the other.

A comparison of practice times between and within various groups yielded no statistically significant differences between Group I and Group II or between the successful subjects of Group I and Group II. However, within Group I it was found that the successful subjects spent significantly less time in practice than did the unsuccessful subjects. This difference was significant at the 5 per cent level of confidence. Within Group II the difference in practice times of successful and unsuccessful subjects was not statistically significant. It is important to note here that although all comparisons throughout the study showed no differences in strength gains that were statistically significant either between Groups, between Successful or Unsuccessful subjects, or between successful subjects within each Group, there is evidence that the strength was developed most efficiently by the successful subjects in Group I (Apparatus).

It is also of importance to note that a greater proportion of the subjects were successful in Group I (Apparatus) than in Group II (Exercise).

CHAPTER VI

SUMMARY AND CONCLUSIONS

Is an increase in abdominal and shoulder strength a factor in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics? If strength is a factor, can it be increased most effectively through a program of prescribed exercises or through exercising on the apparatus? As a result of these questions this study was undertaken and designed in relation to the following fourfold purpose:

(1) to determine whether there was an increase in abdominal and shoulder strength following a prescribed exercise program or an apparatus exercise program

(2) to determine which of the two programs (prescribed exercise or apparatus) was more effective in developing the strength of the abdominal and shoulder musculature as measured by the cable tensiometer

(3) to determine if an increase in abdominal and shoulder strength were a significant factor in the performance of the skin-the-cat skill on the high uneven parallel bar in gymnastics

(4) to determine which of the exercise programs (prescribed exercise or apparatus) was more efficient in terms of the amount of time spent in the actual program.

The sixteen subjects participating in this study were women students selected from two gymnastics classes taught in the Physical Education Department at The University of North Carolina at Greensboro, during the second semester of the 1966-67 academic year. None of the subjects were able to

execute the skin-the-cat skill prior to participation in this study. The subjects were divided into two groups. The groups were statistically equated in terms of total strength (a combination of abdominal and shoulder strength). Both groups participated in separate exercise programs designed to increase abdominal and shoulder strength. Each program involved a maximum of ten minutes of practice two days per week for a period of five weeks. Group I exercised on the high uneven parallel bar; Group II followed a program of five prescribed exercises.

The actual amount of time that each subject spent in practice was recorded each day. Two cable tension strength tests were used to assess measures of abdominal and shoulder strength.

The raw data were treated statistically to determine the significance of any differences between initial and final tests within groups and to determine the significance of any differences between initial and final tests between groups. Statistical techniques were employed to ascertain from the mean practice times the most efficient method of increasing strength. The following results were obtained:

1. The mean gains of abdominal, shoulder, and total strength were statistically significant within Group I (Apparatus).

2. The mean gains of shoulder and total strength were statistically significant within Group II (Exercise).

3. The mean gain of abdominal strength was not sufficient enough to be considered statistically significant within Group II.

4. The differences in abdominal, shoulder, and total strength gains

between subjects of Group I and Group II were not statistically significant.

5. The differences between Successful (those who learned to perform the skill) and Unsuccessful (those who still could not perform the skin-the-cat skill at the conclusion of the study) subjects in abdominal, shoulder, and total strength measures after initial and final testings were not statistically significant.

6. Successful and Unsuccessful subjects had statistically significant gains in abdominal and total strength. Both Successful and Unsuccessful groups failed to show gains which were statistically significant in shoulder strength.

7. The differences in abdominal, shoulder, and total strength gains between Successful and Unsuccessful subjects were not statistically significant.

8. The successful subjects of Group I (Apparatus) showed gains in total strength that were statistically significant.

9. The successful subjects of Group II (Exercise) failed to show gains in total strength that were of statistical significance.

10. The differences in total strength gains between successful subjects of Group I and successful subjects of Group II were not statistically significant.

11. There was no significant difference in the mean practice times of Group I and Group II.

12. There was no significant difference in the mean practice times of successful subjects in Group I and successful subjects in Group II.

13. Within Group I the successful subjects spent significantly less time

in practice than did the unsuccessful subjects.

14. Within Group II the difference between mean practice times of successful and unsuccessful subjects was not significant.

15. Combined Successful subjects spent significantly less time in practice than did the Combined Unsuccessful subjects.

The findings of this study resulted in the following conclusions:

1. Both exercise programs were effective in increasing abdominal, shoulder and total strength.

2. One program was not superior to the other for increasing strength.

3. Unsuccessful subjects gained in strength measures as did Successful subjects. This would appear to indicate that strength increase is a contributing factor, but it also appears that it is not the determining factor of successful performance.

4. The Group I exercise program which was done on the apparatus appears, from the results of this study, to be the most effective in terms of the proportion of successful subjects within that Group as compared to Group II.

5. The Group I exercise program which was done on the apparatus appears, from the results of this study, to be the most efficient program in terms of the time spent in practice by successful subjects within that Group.

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APPENDIX

GROUP I SCORECARD

Front and Back

NAME_____ GROUP I

INSTRUCTIONS: Please record daily practice time in the proper column below.

DATE	TIME

NAME:_____ GROUP I

INITIAL TESTS:
_____Abdominal Muscles
_____Shoulder Muscles

_____T Score

FINAL TESTS
_____Abdominal Muscles
_____Shoulder Muscles

_____T Score

TOTAL PRACTICE TIME:

_____

PERFORMANCE OF SKILL:

_____ Successful

_____ Unsuccessful

(Backside of Scorecard)

GROUP II SCORECARD

Front and Back

NAME_____ GROUP II

EXERCISES:

1. Sit-ups
2. Leg-lifts
3. Push-ups
4. Mermaid
5. Inverted drag

INSTRUCTIONS: Columns 1 - 5 below correspond respectively with the exercises listed above. Please record daily scores in the proper column. Record daily practice time in the "Time" column.

DATE	1	2	3	4	5	TIME

NAME:_____ GROUP II

INITIAL TESTS:
_____Abdominal Muscles
_____Shoulder Muscles

_____T Score

FINAL TESTS:
_____Abdominal Muscles
_____Shoulder Muscles

_____T Score

TOTAL PRACTICE TIME:

_____

PERFORMANCE OF SKILL:

_____ Successful

_____ Unsuccessful

(Backside of Scorecard)

RAW DATA CHART

GROUP I (APPARATUS) - 9 SUBJECTS - AVERAGE TIME = 55 MIN/SUBJECT

Subject Number	Abdominal Strength Scores				Shoulder Strength Scores				Total Strength Scores	
	I. T.		F. T.		I. T.		F. T.		I. T.	F. T.
	X	Tlbs.	X	Tlbs.	X	Tlbs.	X	Tlbs.	T	T
*1	44	70	43	67	33	50	33	50	101.02	99.34
*2	43	67	57	95	37	58	42	65	106.98	130.09
*3	20	30	45	72	21	32	25	37	60.54	89.07
*4	43	67	70	120	35	55	36	57	104.36	136.05
*5	60	101	60	101	40	62	45	72	130.44	140.44
*6	60	101	60	101	35	55	42	65	123.40	133.45
7	35	55	55	92	31	47	35	55	89.61	118.36
8	46	75	59	100	28	41	35	55	94.77	122.84
9	44	70	48	78	42	65	45	72	116.09	127.56

GROUP II (EXERCISE) - 7 SUBJECTS - AVERAGE TIME = 75 MIN/SUBJECT

1	44	70	56	93	34	52	43	67	103.03	130.96
2	32	48	53	88	40	62	45	72	100.77	133.66
3	40	62	38	60	25	37	35	55	83.47	100.45
4	48	78	54	90	39	61	45	72	116.55	134.28
*5	44	70	45	72	35	55	40	62	106.04	114.20
*6	64	106	62	104	44	70	39	61	141.28	131.11
*7	35	55	58	97	33	50	45	72	92.63	138.20

*Signifies Successful Performance
I. T. = Initial Test F. T. = Final Test
X = Raw Scores T = T Scores
Tlbs. = Tension pounds

DESCRIPTION OF EXERCISES

GROUP II

1. Curl Sit-ups - without assistance (done on mats)
   Subject is in a supine position with knees slightly flexed and soles of feet flat on the mat. The hands are clasped behind the head. The subject tucks her chin and flexes the veterbral column as she sits up. The subject performs as many sit-ups as possible without assistance.

2. Leg-lifts - four counts
   Subject is in a supine position with legs extended on the floor. The subject counts as she performs the exercises. On one, the legs flex and the knees tuck to the chest; on two, the legs are extended vertically into the air; on three and four the legs lower from the vertical to a point approximately eight inches from the floor where, without hesitation, they are again tucked on the first count of the next sequence. Each sequence counts and is recorded on the score card as one leg lift.

3. Push-ups - modified (done on mats)
   The subject is in a prone position with knees flexed and feet "free" from the floor. The hands are placed in a comfortable position under the shoulders. The body is held in a straight line from the knees as the arms are extended until weight is supported on hands and knees. From this position, and without hesitation, the arms are flexed and the body is lowered until the face is close to the floor with the body remaining in a straight line. The sequence is repeated in a steady rhythm. Each sequence counts and is recorded on the score card as one push-up.

4. Mermaid
   The subject is in a front leaning rest position (weight is supported by hands and feet with body held in a straight line) with the tops of feet and toes on the floor and legs relaxed. The subject walks forward on hands dragging her feet. The floor is marked in thirty foot sections. These sections are traveled as many times as possible by a subject and the total distance is recorded in the proper column on the score card.

5. Inverted Drag
   The subject is in a back leaning rest position (sitting on floor with legs extended and leaning back with hands on the floor to support the weight). The subject lifts her body and moves backwards dragging feet. The floor is marked in thirty foot sections. These sections are traveled as many times as possible by a subject and the total distance is recorded in the proper column on the score card.

CALIBRATION CHART FOR CABLE TENSIOMETER

Instrument Reading	Tension Pounds	Instrument Reading	Tension Pounds
2	5	41	64
3	6	42	65
4	7	43	67
5	8	44	70
6	10	45	72
7	12	46	75
8	15	47	77
9	16	48	78
10	17	49	80
11	18	50	82
12	20	51	83
13	21	52	85
14	22	53	88
15	23	54	90
16	25	55	92
17	26	56	93
18	27	57	95
19	28	58	97
20	30	59	100
21	32	60	101
22	33	61	102
23	35	62	104
24	36	63	105
25	37	64	106
26	39	65	108
27	40	66	110
28	41	67	112
29	43	68	115
30	45	69	117
31	47	70	120
32	48		
33	50		
34	52		
35	55		
36	57		
37	58		
38	60		
39	61		
40	62		

Figure 1

Testing Apparatus

Figure 2

Position of Tensiometer for Abdominal Strength Test

Figure 1

Testing Apparatus

Figure 2

Position of Tensiometer for Abdominal Strength Test

Figure 3

Strap Position for Abdominal Strength

Figure 4

Position of Subject in Preparation for Abdominal Strength Test

Figure 3

Strap Position for Abdominal Strength

Figure 4

Position of Subject in Preparation for Abdominal Strength Test

Figure 5

Position of Subject During Abdominal Strength Test

Figure 6

Position of Subject and Arm Strap During Shoulder Strength Test

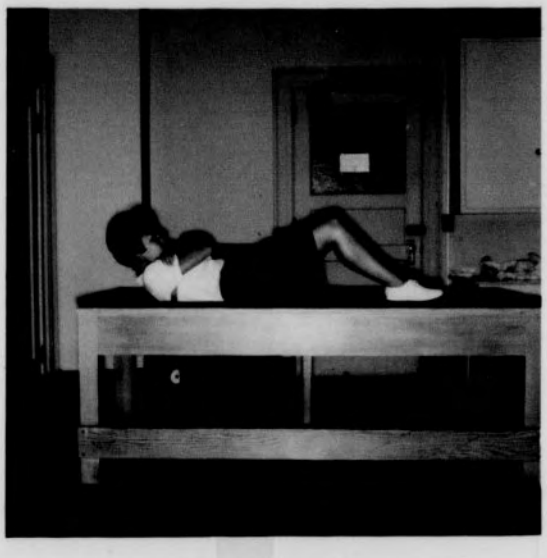

Figure 5

Position of Subject During Abdominal Strength Test

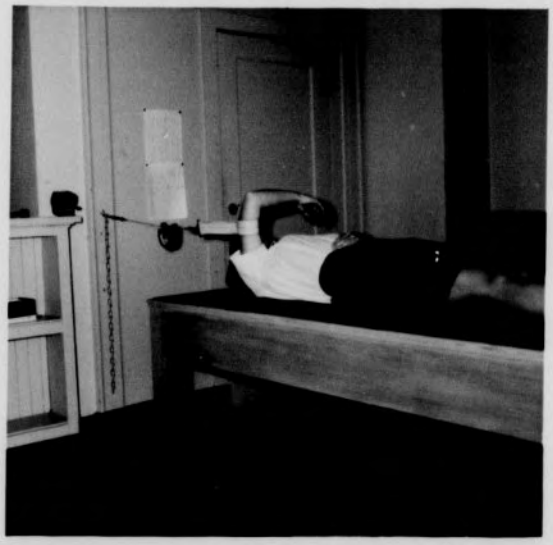

Figure 6

Position of Subject and Arm Strap During Shoulder Strength Test